C. IVHS FIELD EQUIPMENT COMMUNICATIONS REQUIREMENTS AND INTERFACES

St. Louis IVHS Field Equipment Communication Requirements and Interfaces for all Fiber Network

Hub to Field Equipment Connectivity:

Single mode fiber optic cable can be used as the physical medium for hub connectivity to all of the field equipment including the Closed Circuit Television Systems, Vehicle Detection Systems, Variable Message Signs, Ramp Metering Stations, Traffic Signal systems, Weigh-in motion stations, and weather/fog detection devices. Since large distances are present between field equipment and hub sites (>5 miles), single mode rather than multimode fiber optic cable is the recommended physical medium. This is because sinnals transmitted over single mode fiber exhibit less attenuation (loss) over large distances in comparison to multimode fibers.

When compared to the alternative communication methods that use twisted wire pair (TWP) cable, or coaxial cable, fiber optic cable has numerous advantages. Some of these advantages include smaller size and weight, immunity to lightning damage, electrical isolation with no chance of ground loops or potential shifts, absence of spark or shock hazard, and immunity to electromagnetic interference (EMI) and radio frequency interference (RFI). Where possible, and practical, fiber optic connections from the hubs to the low data rate equipment should be configured as multidrop circuits. These connections should be in a “tree” configuration, using the same pairs in the main fiber optic cable to serve more than one field device on the same circuit. Each field equipment unit should communicate with the hub in full duplex mode (bi-directional). Four single mode fibers should be used to connect field equipment sites to the multidrop circuit, with each multidrop circuit representing one communications channel. Two of these fibers should be used for full-duplex communications, and the other two should be provided for redundancy. Single mode optical fiber should also be used as the physical medium for transmitting camera video signals to each hub in a point to point communications configuration. Four fibers should be used to connect each camera to the SONET hub. Two of these fibers will be used for video and data communications between the CCTV sites and the hubs, and the other two fibers should be provided for redundancy.

Vehicle Detection System (VDS):

Description: Microwave radar detectors will be used to provide information such as vehicle presence, speed, count, and vehicle classification in order to maintain a safe and sufficient flow of traffic.

Data Transmission Requirements: All radar detectors make use of a low power microwave radar transceiver. The radar transceivers are tuned and fixed for X-Band frequency operation. These transceivers operate on the principal of Doppler radar theory. Detectors can transmit data via an RS-232 or RS-422 serial port at a speed of 2400 or 4800 bps. A data multiplexer (data field terminal) can be connected to a maximum of 8 vehicle detectors to provide power and collect data via this RS-232 or RS-422 connection. Data will be transmitted to the multiplexers at a rate of 2400 or 4800 bps. A fiber optic transceiver with an RS-232 interface should be connected to the individual detectors or multiplexer to transmit and receive 1200 or 4800 bps serial data to and from a Synchronous Optical Network (SONET) hub via fiber optic cable. All of the vehicle detection data will be collected by a Time Division Multiplexer (TDM) or channel bank via a fiber optic transceiver at the SONET hub. Typically, 20 VDS stations per channel are connected to a multidrop circuit.

Communication Interface: The communication interface between a vehicle detector/multiplexer and fiber optic transceiver should be an RS-232 cable. If a multiplexer is used, the communications interface between the detectors and multiplexer will be an RS-232 cable for distances less than 100 feet and an RS-422 cable for distances greater than 100 feet. The multiplexer and/or detector fiber optic transceiver interface to the SONET hubs via single mode fiber optic cable in a multidrop configuration.

Closed Circuit Television (CCTV)

Description: Closed Circuit Television (CCTV) field units will be located along the roads for visual detection of traffic patterns. Each CCTV unit will consist of a color Charge Coupled Display (CCD) camera; pan, tilt, and zoom lens (PTZ) driver; a control receiver; and CODEC (coder decoder) equipment.

Data Transmission Requirements: Full motion video data from the CCTV field units should be transferred to the traffic operations center via the SONET backbone network. The CCD camera’s analog video signal must be compressed and digitized by CODEC equipment to make it compatible with the digital SONET network. This CODEC equipment can be located in an environmentally controlled cabinet at the CCTV field site. Most CODEC equipment will digitize full motion 10 MHz analog video signals at DS-3 rates (45 Mbps). The DS-3 CODEC also transmits and receivers camera control data to the control receiver via an RS-232 or RS-422 serial port . This data signal is multiplexed with digitized video images and can have transmission rates up to 9600 bps. A DS-3 fiber optic transceiver can transmit these digitized video signals and data signals to the SONET hub over single mode fiber. A DS-3 fiber optic transceiver should be located at the SONET hub to receive this multiplexed signal. The communications architecture between the SONET hub and each CCTV field site should conform to a star topology configuration. The digitized DS-3 video signal and data signal should then be received by a SONET Add Drop Multiplexer (ADM) . The ADM can convert multiple DS-3 electrical signals into OC-12 or OC-48 optical signals for transmission into the SONET backbone network. The OC-12 optical signal has a channel capacity of 622 Mbps, while OC-48 has a channel capacity of 2.5 Gbps.

Communication Interface:
The communications interface between the CCD camera and control receiver/CODEC equipment should be coaxial cables with BNC type connectors at both ends. This same type of cable can be used to connect the CODEC equipment to the DS-3 fiber optic transceiver. An RS-232 or RS-422 cable should be the interface between the CODEC and camera control receiver for the transmission of camera control messages. Single mode fiber should be the interface between the fiber optic transceivers at the CCTV field site and SONET hub.

Highway Advisory Radio (HAR)

Description: A HAR will provide advance driver information. The system will incorporate a 10 watt class D transmitter located throughout the freeway network at HAR stations. The HAR will also have computer control and digital downloading capabilities.

Data Transmission Requirements: A Class D transmitter can transmit audio signals to automobiles via a vertical whip antenna at a bandwidth of 530 kHz. It is recommended that HAR messages be digitally downloaded to the HAR stations from a remote location. Since the HAR stations are computer controlled, digitized audio data can be downloaded to the stations via fiber optic transceivers. This data can be received at the HAR stations using fiber optic transceivers, that receive asynchronous serial data at transmission speeds of 2400 to 9600 bps. These digitized audio messages can be transmitted from a central location to the HAR stations over single mode fiber optic cable via a SONET hub. This fiber optic cable should be linked to a TDM at the SONET hub. Current HAR technology requires that each HAR be connected to the hubs in a point to point configuration, with each HAR representing one communications channel.

Communication Interface: The fiber optic transceivers can receive the digitized audio messages via single mode fiber optic cables that are linked to the SONET hub. RS-232 cable should be the interface between the fiber optic transceiver and the HAR computer control equipment. Coaxial cable should be the interface between the class D transmitter and the vertical whip antenna.

Variable Message Signs (VMS)

Description

The VMS will display real time motorist traffic information about traffic congestion, lane closures, and freeway incidents.

Data Transmission Requirements: The VMS controllers can transmit and receive asynchronous serial data to and from a SONET hub via a fiber optic transceiver at transmission rates of 1200-9600 bps in a multidrop configuration. All of the VMS data can be collected by a Time Division Multiplexer (TDM) at the SONET hub. Typically, 20 VMS stations per channel are connected to a multidrop circuit.

Communication Medium: It is recommended that the VMS controllers be connected to SONET hubs via multidrop single mode fiber optic cable.

Ramp Metering Stations (RMS)

Description: The use of RMS helps to regulate traffic flow onto the mainline freeway during peak travel times.

Data Transmission Requirements The RMS controllers can transmit and receive asynchronous serial data to and from a SONET hub via a fiber optic transceiver at transmission rates of 1200-9600 bps in a multidrop configuration. All of the RMS data can be collected by a Time Division Multiplexer (TDM) at the SONET hub. Typically, 20 RMS stations per channel are connected to a multidrop circuit.

Communication Medium: It is recommended that the RMS controllers be connected to the SONET hub via multidrop cable.

Traffic Signal Systems

Description: Signal controllers will located at intersections throughout the bi-state St. Louis region.

Data Transmission Requirements: The traffic signal controllers can transmit and receive asynchronous serial data to and from a SONET hub via a fiber optic transceiver at transmission rates of 1200-9600 bps in a multidrop configuration. All of the signal controller data can be collected by a Time Division Multiplexer (TDM) at the SONET hub. Typically, 6 signal controller per channel are connected to a multidrop circuit.

Communication Medium: It is recommended that the traffic signal system controllers be connected to the SONET hub via single mode fiber optic cable.

Weather and Fog Detection Devices

Description: Weather and fog detection devices will be located along the mainline freeway at the SONET hub locations for weather data collection.

Data Transmission Requirements: Weather and fog detection controllers can transmit and receive data from the SONET hub equipment via fiber optic transceivers. All of the weather and fog detection data can be collected by a Time Division Multiplexer (TDM) at the SONET hub. Since the weather and fog detection devices are located at each hub, each detection device represents one communication channel and are connected to the hubs in a point to point configuration.

Communication Medium: It is recommended that the weather and fog detection controllers be connected to the SONET hub equipment via point to point single mode fiber optic cable.

SONET Hub Equipment

Each SONET hub should have communications equipment that interfaces with the field equipment. Fiber optic transceivers should be located at each SONET hub to transmit and receive asynchronous serial data from the vehicle detection systems, highway advisory radios, variable message signs, ramp metering stations, and traffic signal systems. Data from the fiber optic transceivers should be transmitted to a Time Division Multiplexer (TDM) via an RS-232 cable. A TDM at the hub allocates time slots to each of these input communication channels. The TDM converts the input analog signals into digital formats using Pulse Code Modulation (PCM) techniques, resulting in signals that have much lower Bit Error Rates (BER) and less sensitivity to noise than comparable analog signals. A typical TDM has 24 analog channel inputs, each with a data transmission rate of 64 kbps. Therefore, the TDM output channel capacity becomes 1.544 Mbps, which conforms to a DS-1 signal level. The SONET ADM will receive this multiplexed digital electrical signal via an electrical patch cord or coaxial cable, and will convert the signal into an OC-12 or OC-48 optical signal for transmission into the SONET backbone. Each of the SONET hubs should be linked together with single mode fiber cables as explained in Technical Memorandum 9.

The SONET ADM will also receive digitized video signals from a DS-3 fiber optic transceiver via a 75 ohm coaxial cable with a BNC connector at both ends. The ADM will convert the input DS-3 signals into OC-12 or OC-48 optical signals for transmission into the SONET backbone.

ADMs use either Time Slot interchange (TSI) or Time Slot Allocation (TSA) multiplexing schemes. TSI is a switching process that moves a time slot from one data stream to a time slot in another data stream. TSA assigns time slots to each ADM node on a dedicated basis and maps service demands (e.g., DS1s and/or DS3s) into these dedicated time slots in the high-speed, multiplexed signal. TSI is the recommended ADM multiplexing scheme for this communications architecture. An ADM with TSI capability is more flexible than TSA for high-speed lines in terms of service and facility grooming. TSI is also inherently supported by larger crossconnect systems, which terminate signals at the DS3 level and cross-connect signals at the DS1 level.

An ADM and digital cross-connect system (DCS) should be placed at the traffic operations center. The ADM can convert a received OC-12 or OC-48 optical signal into a STS-12 or STS-48 electrical signal. The STS-12 or STS-48 signal is then demultiplexed into 12 or 48 STS-1 signals, and converted into DS-3/DS-1 signals. These signals should then be transferred to a digital cross-connect system (DCS). A DCS is a computerized facility that allows DS3 (representing video and camera control data) and DSI (representing VDS, HAR, VMS, RMS, traffic signal system, weather/fog detector data) channels to be remapped electronically. For instance, this system will allow the digital reassignment and redistribution of VDS communications channels into DSO formats. The DCS will provide the traffic operations center access of data on a per-channel basis. DCSs also allow signals to be routed without having to be demultiplexed. Typical applications include: remote diagnostics; maintenance and provisioning; routing and restoration; and network reconfiguration and bandwidth allocation. All of the communications interfaces are depicted in Figure 1.

Fiber Optic Cable Quantization

Tables 1-4 depict the fiber optic communication requirements for the four phases of the St. Louis project: short term, mid-range, long range, and ultimate in Missouri and Illinois. These tables represent approximate fiber counts, and were compiled for cost estimation purposes only. They do not reflect the actual number of fiber that will be installed in the communications system. These counts are based on multipoint communications between the VDS, VMS, Signal Controllers, and RMS and each SONET hub. Point to point to communications is assumed to occur between SONET hubs and each of the following sites: CCTV, HAR, and weather detectors. In addition, the tables show the required point to point fiber optic cables between each of the SONET hubs. In these calculations, four single mode loose buffered fibers are used as the physical medium for one communications channel (two of these fibers are redundant), and for communications between SONET hubs.

The fiber count calculations are made on a hub by hub basis. In other words, approximations are made on the number of required fiber that connect each field equipment site to each hub. This count is related to the number of communication channels between each hub and the field equipment sites. In a multidrop configuration, the fiber optic cable extends the entire distance between a hub and the farthest multidropped field equipment site. However, in a point to point link, fiber counts are based on placement of fiber at incremental levels along the mainline conduit. In these approximations, a uniform increment of 12 fibers per mile is chosen between each hub and field equipment site for point to point communications. Fiber optic cables usually contain fiber counts that are multiples of 12. Such a technique reduces the cost associated with placement of cable with large numbers of fibers over the long distances. In addition, it is assumed that fiber optic cable is spliced every 4 miles, and pull boxes are located every 500 feet. Tables 1-4 summarize the fiber optic cable counts for the different phases of the project.

Once the fiber optic cable is quantified, a cost estimate can be established for fiber optic cable, conduit, splice enclosures, pull boxes, and manholes for the different phases of the project. This is done in Table 5.

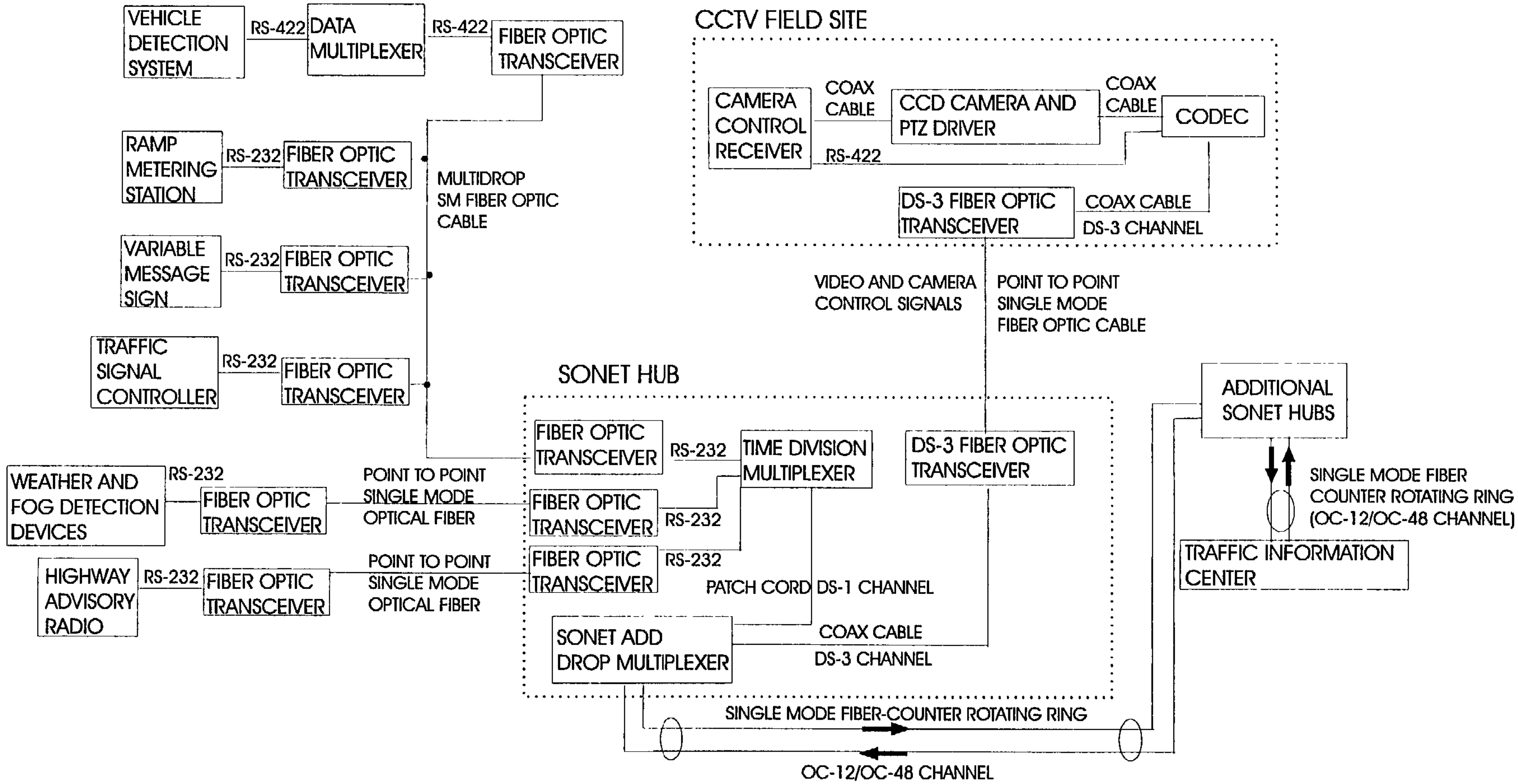

Figure 1- Recommended Field Equipment Communication Interfaces

Table 1												
Short Term Phase (6 Monthes-2 years)												
	Number			Total	# of Channels			Total	# of Fiber (SM)			Total
									(4 Fibers per Channel)			
Hub #	2	3	12		2	3	12		2	3	12	
	MO TIC	70&370	IL TIC		MO TIC	70&370	IL TIC		MO TIC	70&370	IL TIC	
CCTV* (1 per Channel)												
MO	9	12	2	23	9	12		21	36	48		84
IL			6	6			6	6			24	24
Both States				29				27				108
VDS (20 per channel)												
MO	20	50		70	1	3		4	4	12		16
IL			21									8
Both States				91			2	6			8	24
VMS (20 per channel)												
MO	5	4		9	1	1		2	4	4		8
[illegible]			[illegible]	[illegible]			[illegible]	[illegible]			[illegible]	[illegible]
Both States				0				3				12
HAR' (1 per channel)												
MO	0	1		1	0	1		1	0	4		4
IL			0	0			0	0			0	0
Both States				0				1				4
Slgnal Controllers (6 per Channel)												
MO	9	23		32	2	4		6	8	16		24
IL			0	0			0	0			0	0
Both States				0				6				24
Weather Detectors* (1 per Channel)												
MO	1	1		2	1	1		2	4	4		8
IL			1	1			1	1			4	4
Both States				3				3				1;
RMS (20 per Channel)												
MO	4	0		4	1	0		1	4	0		4
IL			0	0			0	0				0
Both States				4				1				4
SONET* backbone												
MO									4	4		8
IL											4	4
Both States												0
Grand Total (Eqt. @ Fiber)												
MO	48	91	2	141	15	22	0	37	64	92	0	156
IL	0	0	29	29	0	0	10	10	0	0	44	44
Both States	48	91	31	170	15	22	10	47	64	92	44	200
Multidrop Fiber Total												
MO									20	32	0	52
IL									0	0	12	12
Both States									20	32	12	64
Point to Point Fiber Total												
MO									44	60	0	104
IL									0	0	32	32
Both States									44	60	32	136
Total Mileage of 4" Conduit												
MO	18	35		53								
IL			12	12								
Both States	18	35	12	65								
Multidrop Cables-Number of fiber in each cable												
(covers entire segment)												
MO	24	36		n/a								
IL			12	n/a								
Point to Point Cable Segments-12 fibers per cable												
(add 12 fiber cable every mile)												
MO	18	35		n/a								
IL			12	n/a								
Number of Pull Boxes (every 500')												
MO	190	370		560								
IL			127	127								
Both States	190	370	127	687								
Number of Manholes (every 4 miles)												
MO	5	9		14								
IL			3	3								
Both States	5	9	3	17								
Splice Enclosures (every 4 miles)												
MO	5	9		14								
IL			3	3								
Both States	5	9	3	17								
* Point to Point Communications												

Table 2																		
Midterm Phase																		
	Number					**Total**	**# of Channels**					**Total**	**# of Fiber (SM)**					**Total**
Hub #	5	6	7	8	10		5	6	7	8	10		5	6	7	8	10	
	270&170	270&70	70&40/64	270 &55	55&64/50		270&170	270&70	70&40/64	70 &5	55&64/50		270&170	270&70	70&40/64	70 &5	55&64/50	
CCTV* (1 per Channel)																		
MO	7	7	5	11		30	7	7	5	11		30	28	28	20	44		120
IL					6	6					6	6					24	24
Both States						36												144
VDS (20 per channel)																		
MO	26	7	7	53		93	2	1	1	3		7	8	4	4	12		28
IL					16	16					1	1					4	4
Both States						109												32
VMS (20 per channel)																		
MO	1	0	0	4		5	1	0	0	1		2	4	0	0	4		8
IL					1	1					1	1					4	4
Both States						6												12
HAR* (1 per channel)																		
MO	0	1	0	0		1	0	1	0	0		1	0	4	0	0		4
IL					0	0					0	0					0	0
Both States						1						0						4
Signal Controllers (6 per Channel)																		
MO	15	12	0	18		45	4	2	0	3		9	16	8	0	12		36
IL					25	25					5	5					20	20
Both States						70												56
Weather Detectors* (1 per Channel)																		
MO	1	1	1	1		4	1	1	1	1		4	4	4	4	4		16
IL					1	1					1	1					4	4
Both States						5												20
RMS (20 per Channel)																		
MO	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0
IL					0	0					0	0					0	0
Both States						0												0
SONET* backbone																		
MO													4	4	4	4		16
IL																	4	4
Both States																		20
Grand Total (Eqt @ Fiber)																		
MO	50	28	13	87	0	178	15	12	7	19	0	53	64	52	32	80	0	690
IL	0	0	0	0	49	49	0	0	0	0	14	14	0	0	0	0	60	186
Both States	50	28	13	87	49	227	15	12	7	19	14	67	64	52	32	80	60	876
Multidrop Fiber Total																		
MO													28	12	4	28	0	72
IL													0	0	0	0	28	28
Both States																		100
Point to Point Fiber Total																		
MO													36	40	28	52	0	156
IL													0	0	0	0	32	32
Both States																		188
Total Mileage of 4" Conduit																		
MO	13	7	7	29		56												
IL					9	9												
Both States						65												
Point to Point Cable Segments-12 fibers per cable																		
(add 12 fiber cable every mile)																		
MO	13	7	7	29		n/a												
IL					9	n/a												
Point to Point Cables-12 fibers per cable																		
(add one additional cable every 4 miles)																		
MO	13	7	7	29		n/a												
IL					9	n/a												
Number of Pull Boxes (every 500')																		
MO	138	74	74	306		592												
IL					95	95												
Both States						687												
Number of Manholes (every 4 miles)																		
MO	4	2	2	8		16												
IL					3	3												
Both States						19												
Splice Enclosures (every 4 miles)																		
MO	4	2	2	8		16												
IL					3	3												
Both States						19												

* Point to Point Communications

Table 3

Long Term Phase

	Number			Total	# of Channels			Total	# of Fiber (SM)			Total
Hub #	1	4	9		1	4	9		1	4	9	
	70&40	270&44	170&40/64		70&40	270&44	170&40/64		70&40	270&44	170&40/64	
CCIV*(1 per channel)												
MO	5	4	5	14	5	4	5	14	20	161	20	56
VDS(20 perchannel)												
MO	45	30	11	86	3	2	1	6	12	8	4	24
VMS (20 per channel)												
MO	1	0	1	2	1		1	2	4	0	4	8
HAR* (1 per channel)												
MO	1	1	0	2	1	1	0	2	4	4	0	8
Signal Controllers (6 per Channel)												
MO	0	27	6	33	0	2	1	3	0	8	4	12
Weather Detectors* (1 per Channel)												
MO	1	1	1	3	1	1	1	3	4	4	4	12
RMS (20 per Channel)												
MO	0	0	0	0	0	0	0	0	0	0	0	0
SONET*backbone												
MO									4	4	4	12
Grand Total (Eqt. @ Fiber)												
MO	53	63	24	140	11	10	9	30	48	44	40	132
Multidrop Fiber Total												
MO									16	16	12	44
Point to Point Fiber Total												
MO									32	28	28	88
Total Mileage of 4" Conduit												
MO	27	13	7 5	47.5								
Multidrop Cables-Number of fiber in each cable (covers entire segment)												
MO	24	24	12	n/a								
Point to Point Cables-12 fibers per cable (add one additional cable every 4 miles)												
MO	27	13	7.5	n/a								
Number of Pull Boxes (every 500')												
MO	285	137	79	501								
Number of Manholes (every 4 miles)												
MO	7	4	2	13								
Splice Enclosures (every 4 miles)												
MO	7	4	2	13								
* Point to Point Communications												

Table 4			
Ultimate Phase			
	Number	#of Channels	# of Fiber (SM)
Hub #	12	12	12
	265&64/5	265&64/50	255&64/50
CCTV* (1 per Channel)			
MO	1	1	4
IL	16	16	64
Both States	17	17	68
VDS (20 perchannel)			
MO	74	4	16
IL	26	2	8
Both States	100	6	24
VMS (20 per channel)			
MO	0	0	0
IL	4	1	4
Both Stat			
HAR* (1 perchannel			
MO	0	0	0
IL	4	4	16
Both States	4	4	16
Signal Controllers (6 per Channel)			
MO	27	2	8
IL	32	3	12
Both States	59	5	20
Weather Detectors* (1 per Channel)			
MO	0	0	0
IL	1	1	4
Both States	1	1	4
RMS (20 per Channel)			
MO	0	0	0
IL	0	0	0
SONET backbone			
MO			4
IL			4
Both States			8
Grand Total (Eqt. @ Fiber)			
MO	102	7	32
IL	03	27	112
Both States	18.5	34	144
Multidrop Fiber Total			
MO			24
IL			24
Both States			48
Point to Point Fiber Total			
MO			8
IL			88
Both States			96
Total Mileage of 4 Conduit			
MO	3		
IL	57		
Both States	60		
Multidrop Cables-Number of fiber in each cable			
(covers entiire segment			
MO	24		
IL	54		
Point to Point Cable Segments-12 fibers per cable			
(add 12 fiber cable every mile)			
MO	3		
IL	57		
Number of Pull Boxes (every 500')			
MO	32		
IL	602		
Both States	634		
Number of Manholes (every 4 miles)			
MO	1		
IL	15		
Both States	16		
Splice Enclosures (every 4 miles)			
MO	1		
IL	15		
Both States	16		
• Point to Point Communications			

Table 4			
Ultimate Phase			
	Number	**# of Channels**	**# of Fiber (SM)**
Hub #	12	12	12
	255&64/50	255&64/50	255&64/50
CCTV* (1 per Channel)			
MO	1	1	4
IL	16	16	64
Both States	17	17	68
VDS (20 per channel)			
MO	74	4	16
IL	26	2	8
Both States	100	6	24
VMS (20 per channel)			
MO	0	0	0
IL	4	1	4
Both States	4	1	4
HAR* (1 per channel)			
MO	0	0	0
IL	4	4	16
Both States	4	4	15
Signal Controllers (6 per Channel)			
MO	27	2	8
IL	32	3	12
Both States	59	5	20
Weather Detectors* (1 per Channel)			
MO	0	0	0
IL	1	1	4
Both States	1	1	4
RMS (20 per Channel)			
MO	0	0	0
IL	0	0	0
Both States	0	0	0
SONET* backbone			
MO			4
IL			4
Both States			8
Grand Total (Eqt. @ Fiber)			
MO	102	7	32
IL	83	27	112
Both States	185	34	144
Multidrop Fiber Total			
MO			24
IL			24
Both States			48
Point to Point Fiber Total			
MO			8
IL			88
Both States			96
Total Mileage of 4" Conduit			
MO	3		
IL	57		
Both States	60		
Multidrop Cables-Number of fiber in each cable			
(covers entire segment)			
MO	24		
IL	24		
Point to Point Cable Segments-12 fibers per cable			
(add 12 fiber cable every mile)			
MO	3		
IL	67		
Number of Pull Boxes (every 500)			
MO	32		
IL	602		
Both States	634		
Number of Manholes (every 4 miles)			
MO	1		
IL	15		
Both States	16		
Splice Enclosures (every 4 miles)			
	1		
IL	15		
Both States	16		
* Point to Point Communications			

Table 5									
St. Louis Mainline Communications Cost Estimate									
Item	Description	Unit	Unit Cost	# of Units MO	# of Units IL	Total Cost MO	Total Cost IL	Both States	Vendor
Short Term Phase									
Conduit	4" Conduit-4 Innerduct System	Mile	$17,000	53	12	$901,000	$204,000	$1,105,000	CARLON
Multidrop Fiber Optic Cable	Single Mode Loose Buffered								
12 Fiber Cable		Mile	$4,200		12		$50,400	$50,400	SIECOR
24 Fiber Cable		Mile	$6,600	18		$118,800	$0	$118,800	SIECOR
36 Fiber Cable		Mile	$9,400	35		$329,000	$0	$329,000	SIECOR
Point to Point Fiber Optic Cable	Single Mode Loose Buffered								
(One additional 12 Fiber cable placed every mile)		Mile	$4,200	53	12	$222,600	$50,400	$273,000	SIECOR
Manholes (Placed every 4 miles)	Placed at each Splice Point	Each	$3,000	14	3	$42,000	$9,000	$51,000	Utility Structur
Splice Enclosures	Fiber Optic Enclosure	Each	$850	14	3	$11,900	$2,550	$14,450	SIECOR
Pull Boxes	Placed every 500 feet	Each	$1,000	560	127	$560,000	$127,000	$687,000	Utility Structur
Subtotal						$2,185,300	$443,350	$2,628,650	
Midterm Phase									
Conduit	4" Conduit-4 Innerduct System	Mile	$17,000	56	9	$952,000	$153,000	$1,105,000	CARLON
Multidrop Fiber Optic Cable	Single Mode Loose Buffered								
12 Fiber Cable		Mile	$4,200	7		$29,400	$0	$29,400	SIECOR
24 Fiber Cable		Mile	$6,600	7		$46,200	$0	$46,200	SIECOR
36 Fiber Cable		Mile	$9,400	42	9	$394,800	$84,600	$479,400	SIECOR
Point to Point Fiber Optic Cable	Single Mode Loose Buffered								
(One additional 12 Fiber cable placed every mile)		Mile	$4,200	56	9	$235,200	$37,800	$273,000	SIECOR
Manholes (Placed every 4 miles)	Placed at each Splice Point	Each	$3,000	16	3	$48,000	$9,000	$57,000	Utility Structur
Splice Enclosures	Fiber Optic Enclosure	Each	$850	16	3	$13,600	$2,550	$16,150	SIECOR
Pull Boxes	Placed every 500 feet	Each	$1,000	592	95	$592,000	$95,000	$687,000	Utility Structur
Subtotal						$2,311,200	$381,950	$2,693,150	
Long Term Phase									
Conduit	4" Conduit-4 Innerduct System	Mile	$17,000	47.5	0	$807,500	$0	$807,500	CARLON
Multidrop Fiber Optic Cable	Single Mode Loose Buffered								
12 Fiber Cable		Mile	$4,200	7.5	0	$31,500	$0	$31,500	SIECOR
24 Fiber Cable		Mile	$6,600	24	0	$158,400	$0	$158,400	SIECOR
Point to Point Fiber Optic Cable	Single Mode Loose Buffered	Mile	$4,200	47.5	0	$199,500	$0	$199,500	SIECOR
(One additional 12 Fiber cable placed every mile)									
Manholes (Placed every 4 miles)	Placed at each Splice Point	Each	$3,000	13	0	$39,000	$0	$39,000	Utility Structur
Splice Enclosures	Fiber Optic Enclosure	Each	$850	13	0	$11,050	$0	$11,050	SIECOR
Pull Boxes	Placed every 500 feet	Each	$1,000	501	0	$501,000	$0	$501,000	Utility Structur
Subtotal						$1,747,950	$0	$1,747,950	
Ultimate Phase									
Conduit	4" Conduit-4 Innerduct System	Each	$17,000	3	57	$51,000	$969,000	$1,020,000	CARLON
Multidrop Fiber Optic Cable	Single Mode Loose Buffered								
24 Fiber Cable		Mile	$6,600	3	57	$19,800	$376,200	$396,000	SIECOR
Point to Point Fiber Optic Cable	Single Mode Loose Buffered	Mile	$4,200	3	57	$12,600	$239,400	$252,000	SIECOR
(One additional 12 Fiber cable placed every mile)									
Manholes (Placed every 4 miles)	Placed at each Splice Point	Each	$3,000	1	15	$3,000	$45,000	$48,000	Utility Structur
Splice Enclosures	Fiber Optic Enclosure	Each	$850	1	15	$850	$12,750	$13,600	SIECOR
Pull Boxes	Placed every 500 feet	Each	$1,000	32	602	$32,000	$602,000	$634,000	Utility Structur
Subtotal						$119,250	$2,244,350	$2,363,600	
Grand Total						$6,363,700	$3,069,650	$9.433.350	